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Covering the Period January 1, 1979 through December 31, 1979

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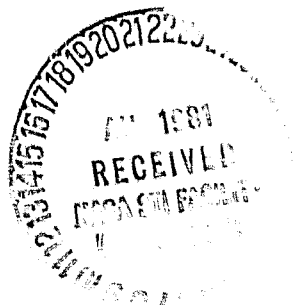
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Menlo Park, California

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PREFACE

The contributions of the National Aeronautics and Space Administration to the advancement of the level of the technology base of the United States are far broader, more complex and more indirect than generally realized. Moreover, the number of NASA contributions that find direct nonaerospace contribution, appear to represent only a small fraction of the large number of contributions by NASA scientists and engineers that have advanced the state of technology in numerous other scientific fields.

This contribution has been made possible, in part, by the activities of NASA's Technology Transfer Program, which provides a link between the developers of aerospace technology and those in either the public or private sector who might be able to employ the technology productively. Maintaining and strengthening this link is, in part, the responsibility of NASA-sponsored applications teams who work actively in specific areas of public concern, helping to match problem and solution and following through to ensure the most effective utilization of the transferred technology.

One such team resides at SRI International, Menlo Park, California. The SRI Technology Applications Team is primarily concerned with problems facing the transportation industry, although its activities encompass aspects of energy, housing

and public safety concerns as well. Members of the SRI Team routinely work with a user community including representatives of the railroad and rapid transit industry, state highway departments, port authorities, correctional officials and representative federal agencies such as the U.S. Department of Transportation, and the National Institute of Corrections, to name a few. In addition, Team members maintain active contact with NASA's scientific community at all NASA centers throughout the United States and continually strive to bridge the gap between the key technological needs of the user and the available technology or expertise at NASA.

This report highlights key transfers and accomplishments of the SRI Team over recent years. In it, we have tried to illustrate key team transfers as they relate to major NASA missions. It is by no means all inclusive, but is merely intended to maintain user awareness of the vast NASA storehouse of knowledge available for utilization. NASA and the SRI Team welcome any follow-up requests for more detailed information and will be pleased to pass your request on to the most appropriate NASA scientist or facility.



Dr. Tom Anyos, *Director*
Technology Applications Team
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Menlo Park, California

INTRODUCTION

This past year has been an especially active one for the SRI Technology Applications Team. During the year the team has: successfully encouraged further applications of NASA's zinc-rich corrosion-control coating; applied NASA bimodal/multimodal filler loading technology to the solution of a rapid-transit industry problem and the subsequent commercialization of a new wire and cable formulation; brought the novel MODCAN crash barrier to the commercialization stage, having identified a potential manufacturer and a state willing to cooperate in the demonstration of the technology; introduced the rapid transit industry to a new, effective, commercially competitive fire-resistant foam developed under NASA sponsorship; and has worked closely with corrections officials to initiate an increasingly successful program designed to transfer NASA technology for the solution of many of the technological problems facing correctional institutions in the U.S. today.

In addition to these activities, SRI Team members have vigorously pursued the transfer of an even wider variety of NASA technologies. Working through the RTOP (Research and Technology Objectives and Plans — an internal pro-

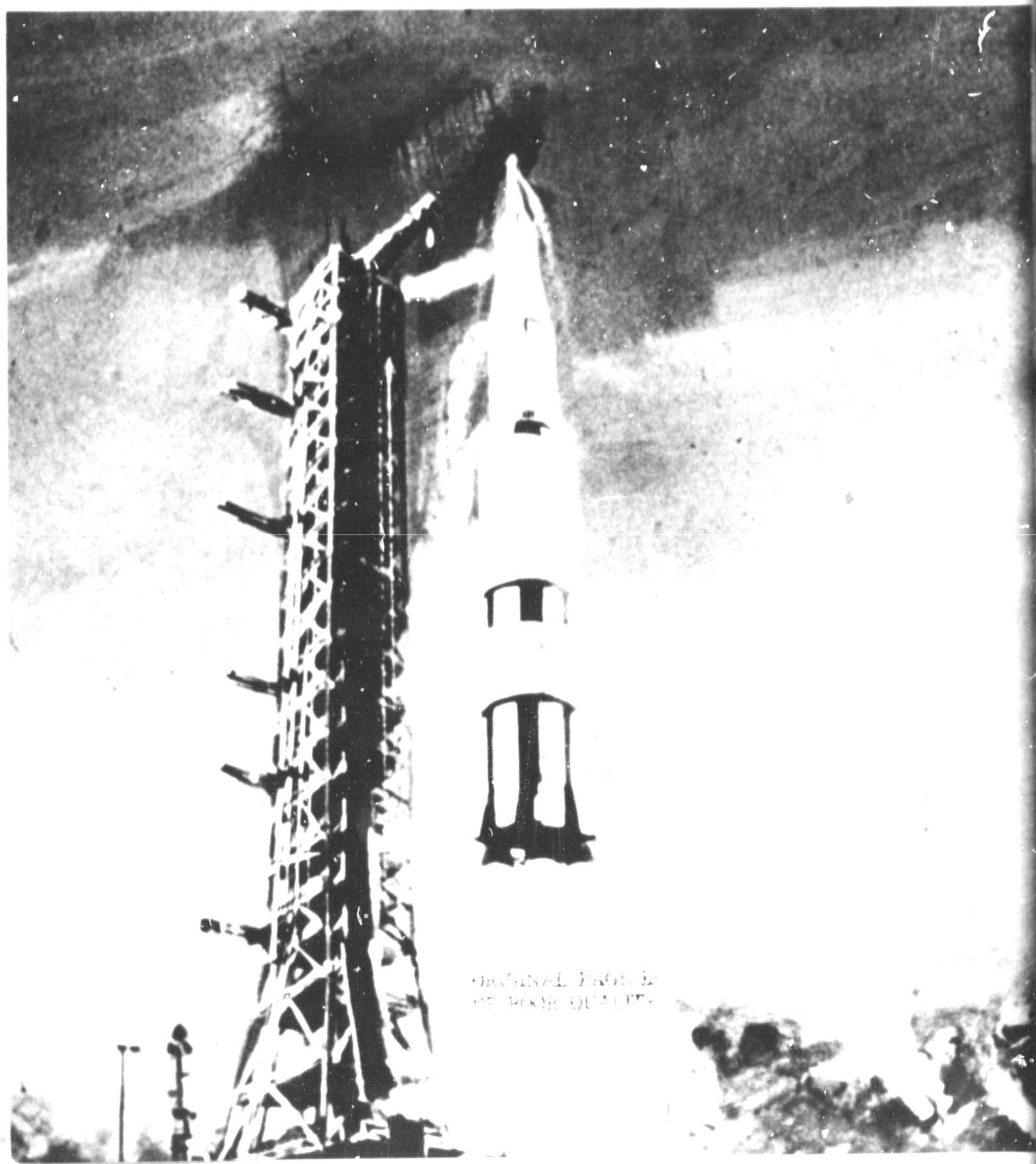
posal mechanism to obtain program funding for projects of national interest and need) route, this coming year the SRI team hopes to work with engineers and scientists at all NASA centers, developing technologies: for new simulation programs for training heavy machinery operators and law enforcement officers; for the use of grey water in correctional institutions for conservation of natural resources and cost savings; which facilitate the release of frozen coal from railroad hopper cars and barges; that assist in aircraft navigation; for weighing trucks while they are in motion; for protecting bridge decks from corrosion; developing technologies: leading to the use of remotely piloted vehicles (RPVs) for surveillance and law enforcement.

We continue to believe that the team approach is truly one of the most effective techniques available for the transfer of federally-funded technologies for the solution of public sector needs, and look forward to an ongoing and continued successful relationship with the NASA Technology Transfer Program.

Many of the SRI Team's key transfer efforts are illustrated on the following pages.

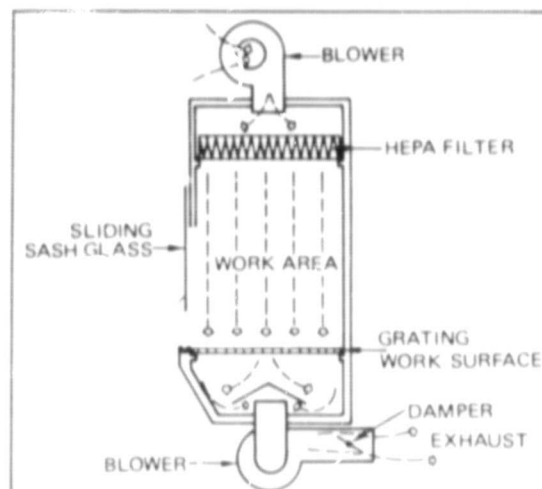
National
Aeronautics and
Space
Administration

NASA Missions



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Preflight



CLEAN AIR FOR TOLLBOOTH OPERATORS

Toll collectors on bridges and turnpikes may be subjected to atmospheric pollution from engine exhaust fumes. These fumes are especially strong in the vicinity of tollbooths as vehicles are decelerating through the booth and quickly accelerating again after the toll is paid.

Recognizing this potentially hazardous situation, the Department of Transportation in the State of Washington decided to include air purification equipment in its tollbooth designs. The problem of identifying and selecting the proper air purification equipment or design was undertaken by the SRI Team at the request of Washington DOT officials.

A search of the data base identified three NASA documents on clean room technology. From one of these documents (SP-5045, "Contamination Control Principles"), Washington engineers found NASA air diffusion technology and laminar air flow designs which they subsequently incorporated into tollbooths on the Evergreen Point Bridge near Seattle. The incorporation of this NASA technology effectively purified the air within the tollbooth and significantly reduced a potential health hazard without causing drafty or turbulent conditions within the booth. The design has been made available to all interested highway departments in the United States.

HIGHWAY/RAILWAY PROFILE MEASUREMENT

Road profiling, or the study and measurement of surface stress and wear, has been of great interest to highway and railway engineers for several years. Early identification of potential and actual instances of road deterioration can save considerable money, time, and energy.

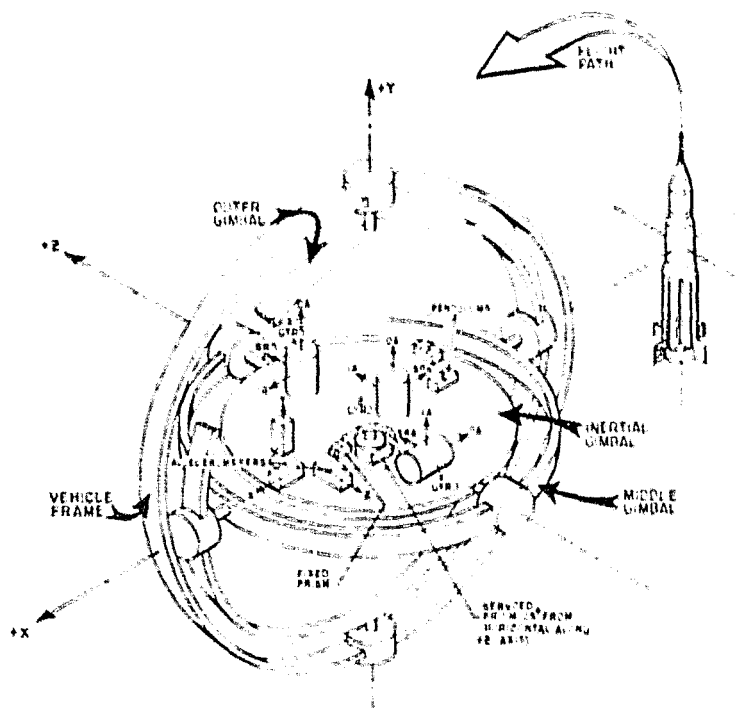
The first attempts at road profiling involved a test vehicle with an independently suspended fifth wheel. This method was limited in sensitivity, accuracy, and dimension, primarily because of its reliance upon a mechanical link between the wheel and the recorder.

A later method of road profiling involved the use of a single-axis inertial reference, such as a vertical gyro or accelerometer in conjunction with other sensors. Although this method provides vehicle roll information, it lacks the dimensional contingents of pitch and yaw.

A vastly improved method of road profile

measurement in three dimensions has been developed by NASA space program research on gyro stabilized guidance and control systems. This method uses an inertial platform which consists of a double-gimbal-mounted plate. The plate is rotationally stabilized by means of three independent gyroscopes whose axes are aligned along an orthogonal coordinate system. In addition, three accelerometers, also mounted on the stabilized plate and orthogonally oriented, provide inertial reference signals to a data acquisition system. The entire platform is then isolated from the test vehicle's suspension system.

The Southwest Research Institute in San Antonio, Texas, successfully used a prototype of the NASA platform in a test program directed toward the identification of roadway conditions which lead to hydroplaning. A report by Southwest Research Institute will be released in 1980.



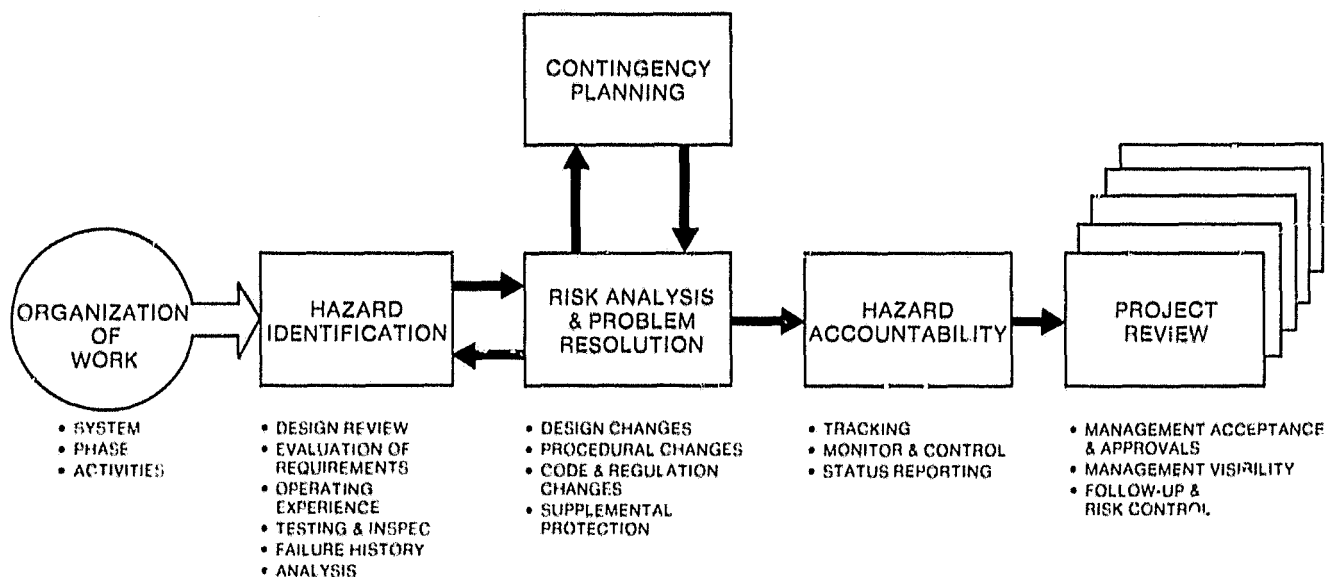
A SYSTEMS ASSURANCE PROGRAM FOR THE RAPID TRANSIT INDUSTRY

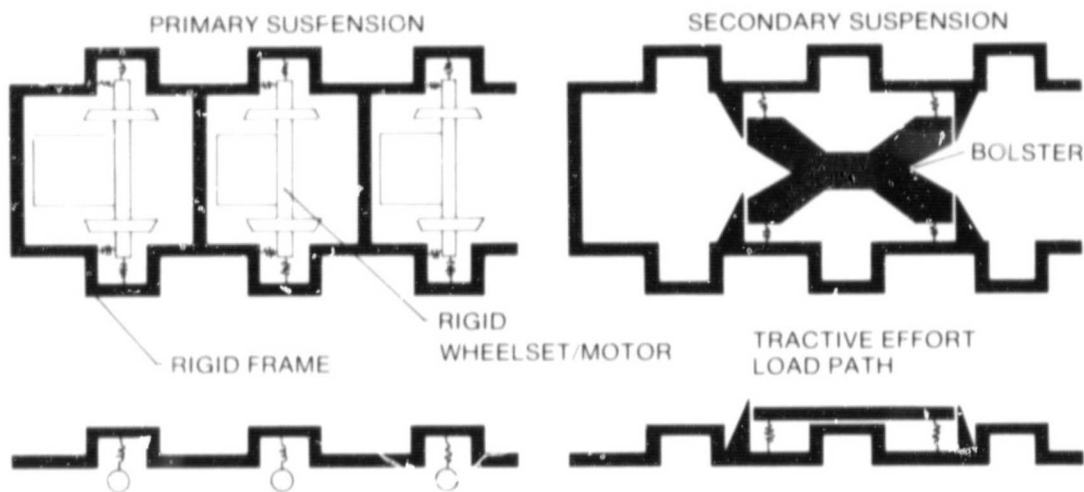
The growing need for urban public transportation in the U.S. has prompted significant expansion and construction of mass transit systems in several parts of the country. This activity has resulted in the introduction and installation of many advanced and new technologies to already complex transit systems. The addition of these technologies, however, can lead to increased maintenance requirements, unexpected failures, and less system availability. To overcome these problems, systems assurance (e.g., quality assurance, reliability, maintainability, system safety and security, and system life-cycle cost) must be designed and integrated into the overall transit system.

Much of today's systems assurance technology was conceived and developed by the aerospace

industry. NASA's expertise in the application and integration of systems assurance in such complex programs as Apollo, became an invaluable tool for the transit industry to find and transfer space management technology.

The design and construction of the Metropolitan Dade County Rapid Transit System became the target for the technology transfer of NASA's Program Control System. This transfer is being accomplished by the interaction of NASA with the Urban Mass Transportation Administration, Dade County, and SRI. A separate document entitled, "The Transfer of NASA Technology with Transit System Development, A Case Study in Metropolitan Dade County, Florida" which details this technology transfer, will be available in early 1980.





TRACK/TRAIN DYNAMICS AND LOCOMOTIVE DYNAMICS

The Association of American Railroads (AAR) recently administered a National Research Program to develop data and to define options for controlling the dynamic aspects of train operations. This program led to generally improved operating procedures and equipment design.

The SRI Team learned of the Track/Train Dynamics Program during the normal course of its activities with the AAR and the railroad industry. SRI informed the AAR and the Federal Railroad Administration (FRA) of the valuable contribution NASA could make to their program, with regard to data acquisition and analysis, instrument development, and dynamic modeling. Subsequently, an interagency agreement was signed between NASA and the FRA for the services of Marshall Space Flight Center (MSFC) in support of specific tasks of the overall program.

The objective of the NASA/FRA project was to define an experimentally verified mathematical

model of the dynamic properties of an 80-ton open hopper freight car and its ride control trucks, for use in dynamic analysis of curving and hunting in response to track irregularities through the interaction mechanisms existing between car, truck, and track. A corollary objective was to establish the techniques that may be used in future test efforts to evaluate additional configurations.

In addition, under a separately funded program, analytical models have been developed which can now predict locomotive behavior for various conditions such as entry and exit out of a curve. Furthermore, this program has produced high fidelity test-verified models that can help to clarify the derailment problem.

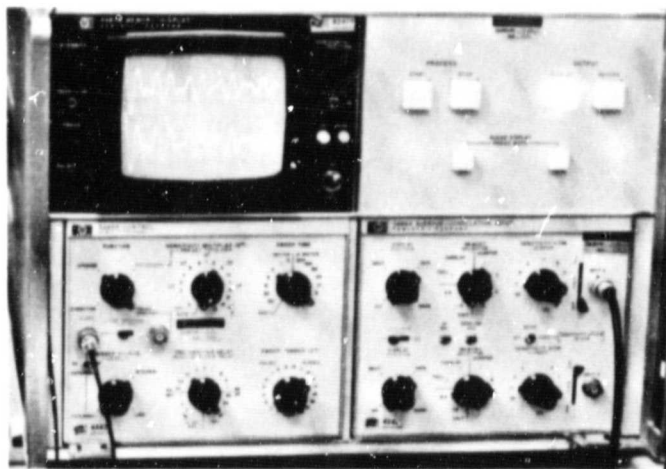
The outcome of complex analytical efforts, truck characterization tests and road tests have been most promising, and have been transferred for the benefit of the railroad industry.

NONDESTRUCTIVE BRIDGE INSPECTION

The government requires that the more than 500,000 bridges on U.S. highways be inspected semiannually for structural integrity. Inspection techniques in current use are generally slow and cumbersome with some even impeding traffic flow.

A new inspection technique, developed at ARC, can monitor the random vibration signature of a structure by using accelerometers as sensors that feed into a correlation computer. This technique has been tested under a joint NASA/FHWA project in the laboratory as well as on several San Francisco Bay Area bridges. The technique named "RANDOMDEC" detected cracks as small as 1/4 inch. Allowances must, however, be made for deviations in structural members.

Responsibility for further effort has been assumed by private industry. The SRI Team considers the technology transferred.



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FROZEN HOPPER CAR RELEASE SYSTEM

Coal and iron ore freeze in railroad open-top hopper cars during the winter in the North. To unload these cars, time-consuming, costly, and often car-damaging processes are used. Most northern railroads and users of coal and iron ore need a product or process to prevent coal and iron ore from freezing in open-top railroad hopper cars or to free frozen carloads inexpensively for unloading.

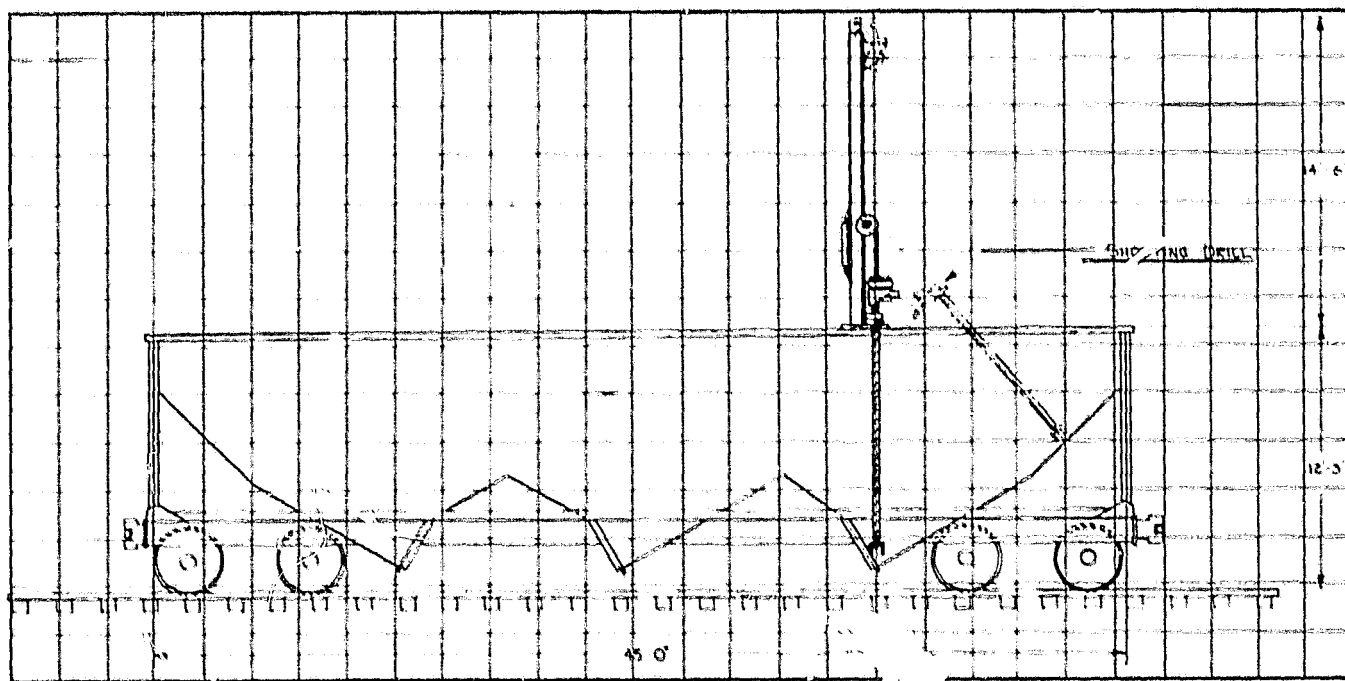
In response to this need, the NASA Technology Applications Team at SRI International solicited innovative concepts from NASA scientists and engineers by distributing a NASA Technology Utilization Opportunity (i.e., problem statement) to the ten NASA field centers. A pyro/propulsion support engineer, Melvin H. Lucy, at Langley Research Center (LRC) responded to the problem statement with his concept of using a controlled gas detonation to create an instantaneous localized shock to break up the frozen coal or iron ore.

In Mr. Lucy's approach, a probe would introduce a explosive mixture of two gases into a rela-

tively small and confined volume of the porous bulk material. The gases would be mixed at the lance tip, where the mixture would readily enter the aggregate. The mixture could then be detonated with an electric spark, creating an instantaneous, localized shock to break up the material in and around the gas introduction zone.

This system could be packaged as a portable unit for individual cars or as a remotely operated system with multiple probes in a facility used for a train of cars. Single, controlled, small detonations appear to be a preferred mode of operation. The procedure should only require a few minutes per car and should not affect material properties or reduce moisture content. No large-scale energy release is involved, hence little or no damage to the hopper car should occur.

The LRC TU Office is planning to support an applications project to build a prototype explosive gas lance and then to conduct tests on loads of frozen coal and iron ore.



HIGHWAY SKID-RESISTANCE MEASUREMENT

Skidding is a major contributor to traffic accidents, and the importance of skid-resistance measurement is acknowledged by the highway departments. In fact, the Highway Safety Act of 1968 states that "every state in cooperation with county and local governments shall have a program for resurfacing . . . sections of streets and highways with low skid resistance." To prove adequate skid resistance, accurate measurements of existing road surface conditions must first be made.

Skid Testers are commercially available from a number of sources. However, the high cost of these units ranging from \$60,000 to \$200,000, prevents counties, cities, and even some states from purchasing the test equipment. Therefore, in many parts of the country, only major highways are tested for skid resistance.

A pulsed braking technique employing a diag-

onally braked vehicle (DBV) to measure the skid resistance of runways has been developed at NASA's Langley Research Center by Messrs. Walter Horne and Everett Browne. The vehicle used was a Ford Fairlane Tudor sedan with a fifth wheel for monitoring distance and velocity plus instrumentation for measuring the angular velocity of the fifth wheel. The vehicle was equipped with ASTM-E501 test tires and valves for all wheels, plus two sets of test instrumentation — one using an inexpensive Tapley meter and the other using longitudinal accelerometers plus a 2-channel chart recorder. Total cost for the system is less than \$2,000 if only the Tapley meter is used and about \$6,000 with accelerometers, not including the vehicle. The NASA technique provides accurate skid testing (as proven during comparison testing at the Texas Transportation Institute), taking both longitudinal and lateral measurements.



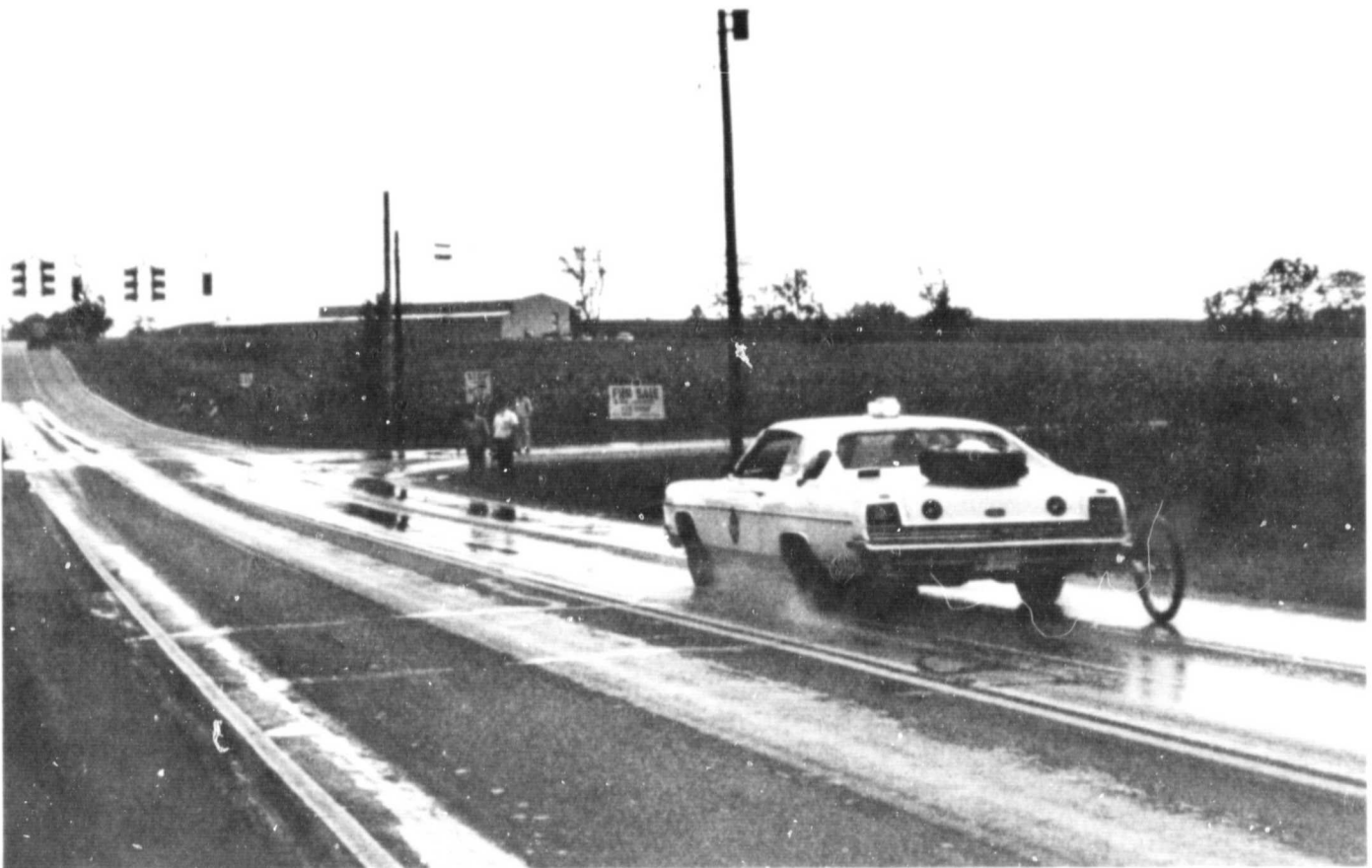
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The diagonally braked vehicle and pulsed braking technique were included in a Federally Coordinated Program to test highway intersections in Dayton, Ohio for skid resistance. Twelve intersections with high accident rates were tested, including several on down grades. Measurements were comparable to those made with an expensive skid trailer.

A survey of all 50 state highway departments, performed by the SRI Team indicated that fewer

than 100 skid testers are currently in operation and that an immediate market would exist for about 250 additional testers if a tester (vehicle plus instrumentation) were available for about \$15,000. For a widespread program to test all roadways, another 3,000 skid testers might be needed.

Documentation and a detailed description of the system have been sent to many interested parties and continues to be available from NASA or the SRI Team.





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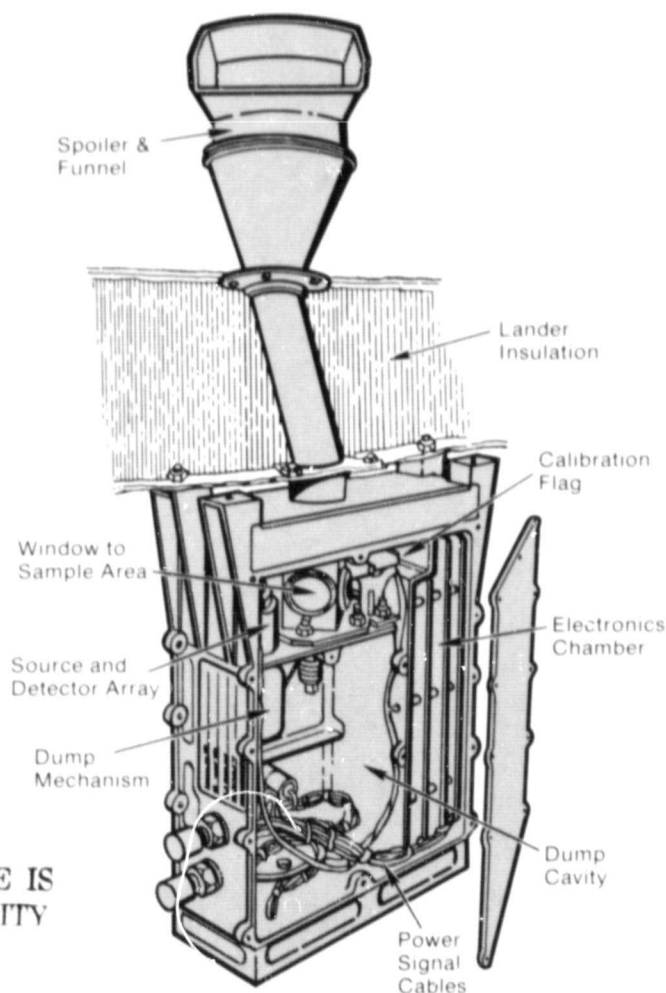
Viking

DIFFERENTIATION OF SHALE TYPES

The shale found in large quantities in many southeastern states is used extensively in highway construction. This shale encompasses a broad range of sedimentary rocks which vary in color, structure, and chemical composition. Most important, however, are the shear-strength characteristics of shale, ranging from rock-like to clay-like. Unfortunately, no dependable method has been found for identifying different shale types. Hence, some highways have suffered embankment slides, slope shifts, pavement heaving, and pavement collapse, as a result of the use of the wrong shale type.

Current shale testing methods require that hundreds of road samples be extracted and carefully marked for laboratory analysis. This process is time-consuming and expensive.

The SRI Team, in seeking an advanced technology that would enable the construction of a portable instrument capable of identifying different organic shales, found that the Viking X-ray Fluorescence Spectrophotometer developed by NASA's Langley Research Center and the Martin Marietta Company, appeared ideally suited to this need. The use of such an on-site device would substantially expedite the construction and ensure the safety of roads and highways in the southeastern U.S. The program is now in the demonstration stage and commercially available devices may be available in the very near future.



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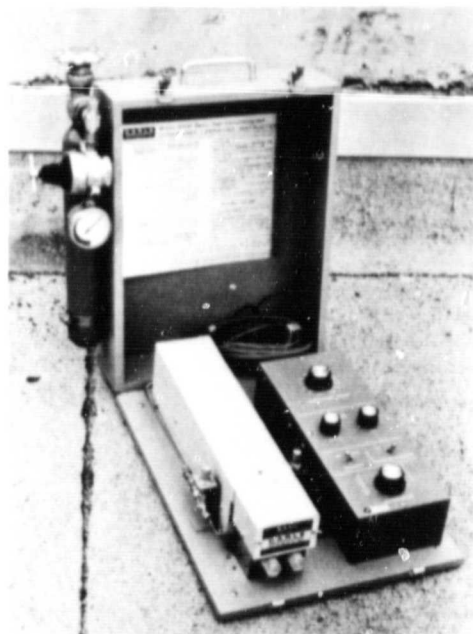
SOIL MOISTURE ANALYSIS FOR HIGHWAY CONSTRUCTION

Public works and highway departments have an immediate need for a rapid, accurate, and inexpensive technique for measuring soil moisture before road construction begins. Proper compaction of the road bed to prevent road collapse depends on accurate moisture measurements. Most current techniques have two drawbacks: they are slow (overnight drying in an oven), and they can handle only very small samples. Because most soil samples are heterogeneous and may contain large, agglomerated particles, small sample measurements are inaccurate.

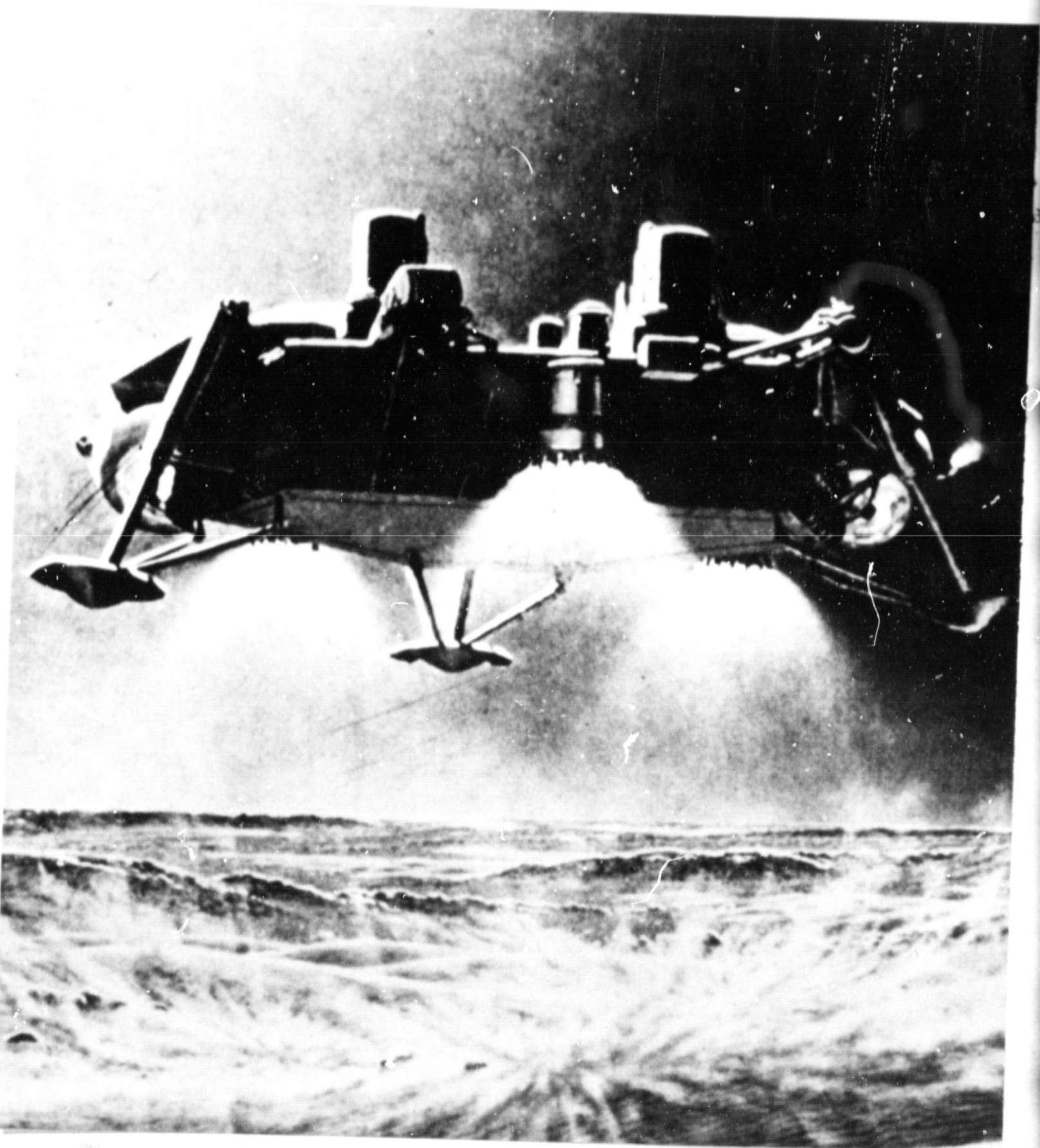
A simple and rapid analytical technique for the analysis of moisture content of soils has been developed as part of the Viking and post-Viking studies at NASA's Ames Research Center. This technique entails extraction of moisture from a soil sample by means of a solvent that is subsequently analyzed with an inexpensive gas chromatograph (GC).

A rugged portable GC unit has been built for speedy (less than 1 hour) on-site analysis of soil. Initial tests have been conducted by Santa Clara County (California) public works personnel. Moisture measurements made by the NASA GC technique were compared with those obtained by oven drying. Although the sample soil, a clay with rocks up to 1 in.³ in size, was considered by the U.S. Federal Highway Administration to be difficult to analyze, no problems were encountered using the NASA technique. In fact, readings with 99.8% repeatability were obtained. In a field demonstration conducted by the Texas Department of Highways, the technique was found to be valid.

Discussions have been initiated concerning the manufacture of a GC kit (including an 11-lb. recorder, an integrator, pint-size bottles, needles, a gas tank and the rugged, portable GC) for use by highway personnel. For the entire 40-lb. kit, a price of a little over \$1,000 has been estimated. A survey of other manufacturers of simple gas chromatographs revealed a price range of \$1,000 to \$4,000 for the GC alone, none of which is built for field use.



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Apollo

ELEMENTAL ANALYSIS OF HIGHWAY RUNOFF STREAM CONTAMINANTS

Motor oil, exhaust carbons, and tire markings are the residue of vehicular traffic on our nation's highways. With each rainfall, these residues are washed to the sides of the roadway where they seep into the groundwater. Highway engineers and environmentalists are concerned about the effect of this groundwater contamination on public health; the installation of drains at excessively contaminated locations is planned. However, these sites must be identified before preventive measures can be taken. A rapid method of analyzing the level of groundwater contaminants is needed. The same need exists for rapid analysis of rivers and streams to quantify contamination.

A technique for the rapid analysis of ground

surface elements has been developed and used by NASA for *in situ* lunar soil analyses without the taking of samples. The heart of the technique is a computer program for on-line data analysis of spectral measurements. More than 30 elements can be identified and quantified by the program. The program can be used to analyze X-ray, gamma-ray, and other spectral measurements. Work is under way at Goddard Space Flight Center on the neutron gamma-ray probe necessary for the remote gathering of raw data needed by the program.

As this technology approaches commercialization stage, the SRI Team will intensify its transfer efforts to assure the utilization of this important technology along the nation's highways.

PERIODIC TABLE

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3 Li	4 Be														5 B	6 C	7 N	8 O	9 F	10 Ne							
11 Na	12 Mg	IIIB	IVB	VB	VIB	VIIIB	VIII					IB	IIIB	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar								
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr										
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe										
55 Cs	56 Ba	57 *La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn										
87 Fr	88 Ra	89 #Ac																									
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58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu														
90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr														

CRASH BARRIERS

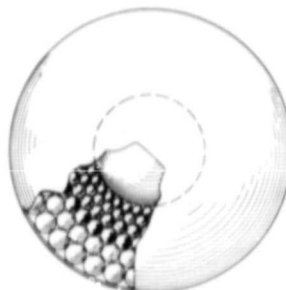
Highway accidents involving vehicle collisions with fixed objects (trees, utility poles, embankments, bridges, etc.) account for thousands of injuries and fatalities each year. A new and effective crash barrier is needed to provide protection against impact damage, and prevent rebound by slowing the vehicle incrementally and then bringing it to a controlled stop.

After considerable research, the SRI Team selected a modular design developed by NASA (Tech Brief 72-10712) for the Lunar Lander Impact Alternator (Lander Foot). This NASA basic design was translated into a unique low-cost configuration employing aluminum cylinders (beverage cans) contained in a tear-resistant bag and a collapsible plywood and steel container. A one-module (3' x 3' x 6') prototype of this barrier, called MODCAN, was fabricated at NASA's Jet Propulsion Lab (JPL). Vigorous testing at JPL confirmed the barrier's success in reducing the impact and danger imparted to vehicle occupants during a crash with a stationary object.

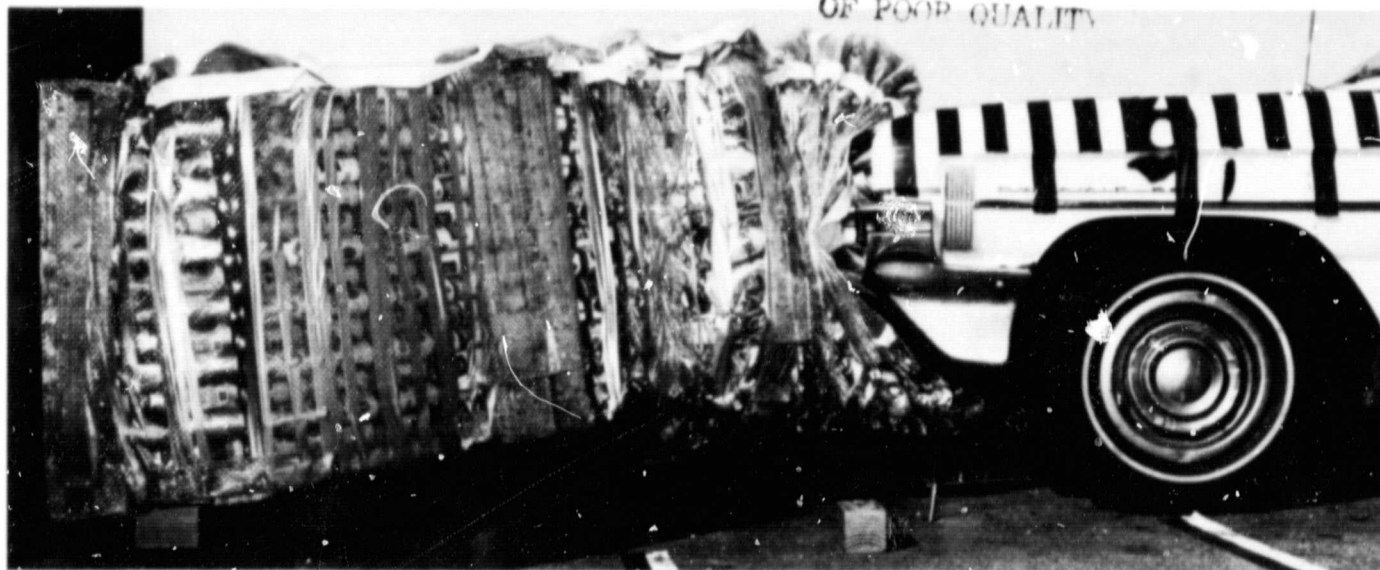
Drivers of test vehicles were subjected to potentially dangerous decelerations at 30 mph, and in no case did the driver experience more than

slight, momentary discomfort. Extrapolation of test data suggests that the one-module JPL barrier, when installed in front of a roadside tree or telephone pole, would also have met safety requirements at 40 mph. (A larger model would be needed for speeds in excess of 40 mph.)

The implementation of this technology transfer by the SRI Team has begun; plans for construction of the one-module barrier have been released to a small business concern in Arlington, VA, which will build several modules for installation and test on a Pennsylvania highway. With the success of these tests, extensive use of the MODCAN barrier, on a national level, is anticipated.



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CORROSION PROTECTION COATING

Because of exposure to harsh salt spray, coastal bridges require greater corrosion protection than do inland bridges. Currently available coatings provide less than 10 years of protection on bridges near coastlines, compared to 20 years of protection on inland bridges.

Most current anti-corrosion coatings for bridge structures consist of zinc or aluminum dust that is mixed with and suspended in an organic or inorganic binder during application. The rather complex preparation of the final coating formulation is done on site. This expensive process prompted the transportation industry to seek a more easily applicable coating at a reasonable price.

A search of relevant NASA literature by the SRI Technology Applications Team revealed that a zinc-rich coating using a potassium silicate binder would provide excellent corrosion protection. This coating was developed at Goddard Space Flight Center (GSFC), and was reported in NASA TSP 70-10060 and U.S. Patent 3,620,784. Unlike most commercially available zinc-rich inorganic coatings, the GSFC coating is especially easy to mix

and requires no straining before application, thus providing considerable savings in labor costs. The coating has a water base for additional savings in materials costs as well as fire resistance and freedom from toxic fumes.

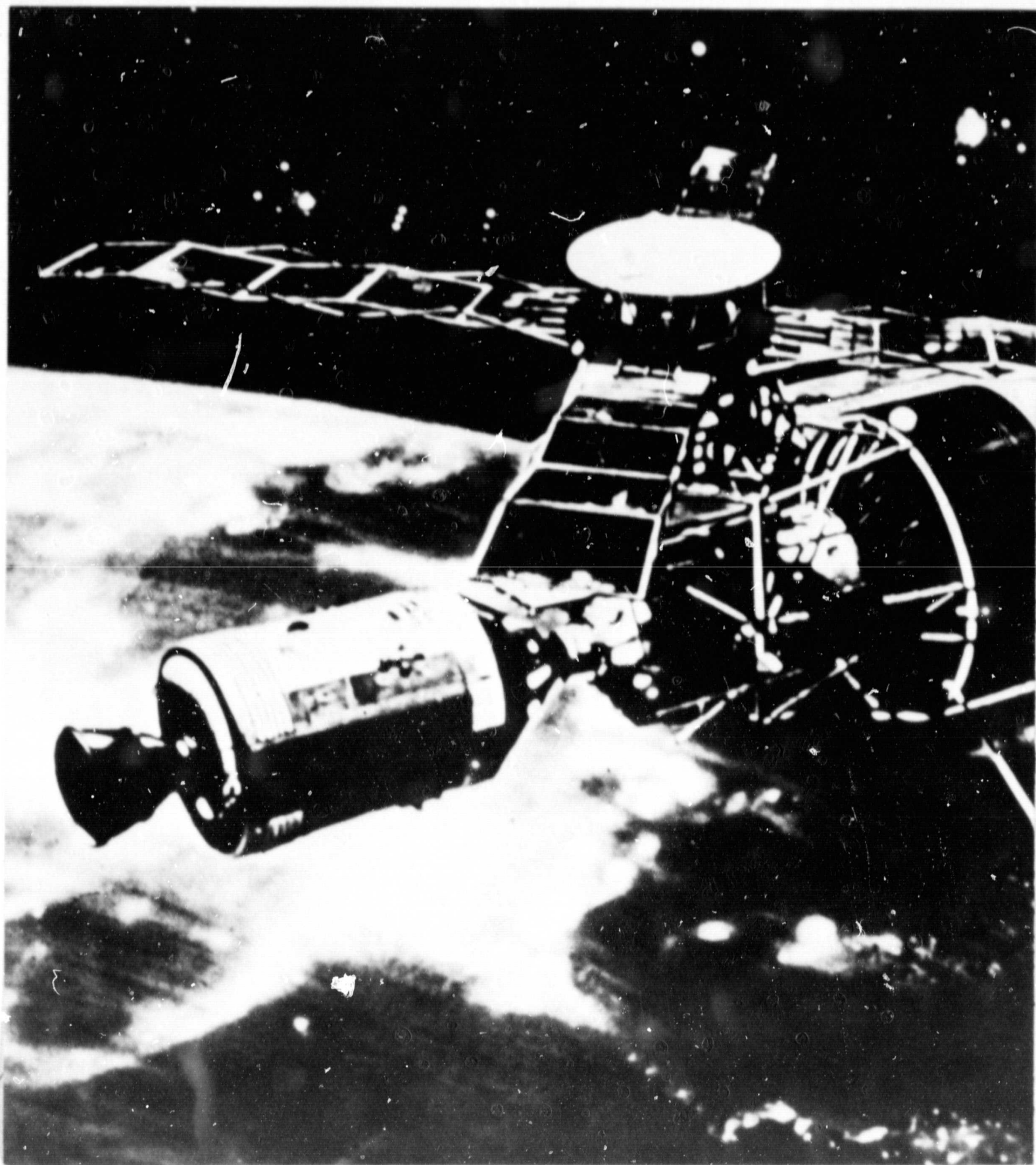
Testing of the GSFC coating by NASA's Materials Testing Branch at Kennedy Space Center has been completed. The summary report concludes that the coating is "equivalent to the best commercially available inorganic zinc-rich coatings in atmospheric corrosion resistance, abrasion resistance, and heat resistance."

Several well-established manufacturers are considering the possibility of adapting the basic formulation of the GSFC coating to specific markets, with the objective of patenting their individual adaptations. Recent formulations appear to yield additional advantages — such as the ability to adhere to hot welds.

Because the GSFC coating has already reached the commercial stage as a superior alternative to contemporary corrosion coatings, the technology transfer effort by SRI is complete.

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Skylab

ROLLER BEARING FAULT DETECTION

According to DOT statistics, failed wheel bearings are a major cause of train derailments in the United States today. Approximately 400 derailments per year are caused by overheated bearings alone.

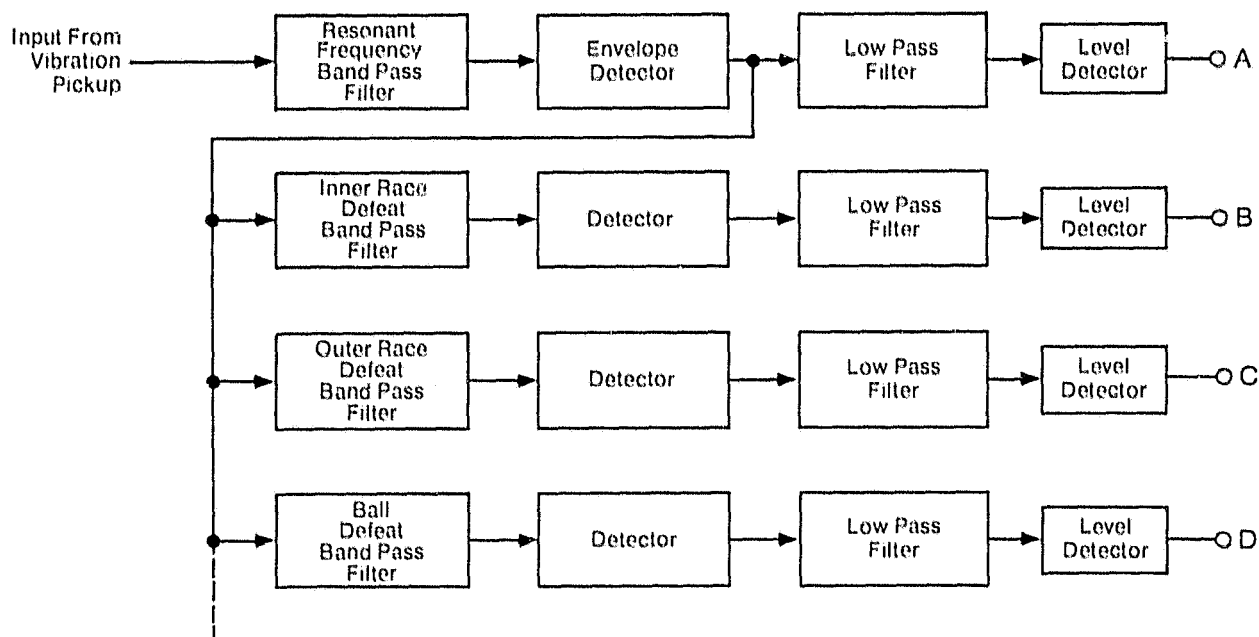
Most of the two million rail cars currently in use are equipped with roller bearings. These roller bearings have been replacing the less efficient journal bearings over the past several years. The older method of monitoring these journal bearings by trackside bolometers is becoming obsolete. New methods for the detection of bearing failure are crucial in preventing impending accidents.

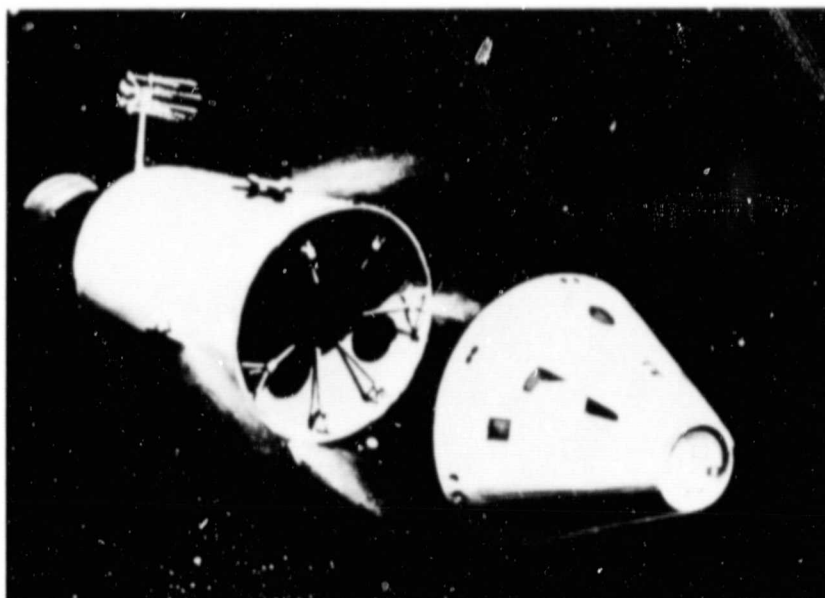
Working with the railroad industry, the SRI Technology Applications Team searched NASA's technical data base and uncovered a promising solution to the bearing problem. Two articles were particularly pertinent: NASA Tech Brief 72-10689,

"New Detection Method for Rolling Element and Bearing Defects," and NASA Tech Brief 72-10494, "A System for Early Warning of Bearing Failure." A high-frequency vibration technique originally designed for monitoring control moment gyros in the Skylab Program could be applied to the railroad industry.

After a favorable evaluation of the NASA monitoring system was received from the Association of American Railroads Research and Test Department, a program was developed to adapt the technique specifically for railroad use. This engineering effort was funded by NASA's Technology Utilization Office, and by Shaker Research Corp., Ballston Lake, New York. At present, a refining of the original prototype design has resulted in a commercially acceptable package for manufacture and marketing as a laboratory or shop instrument, with a trackside package being under development.

New Detection Method for Rolling Element and Bearing Defects





DOCKING SYSTEM FOR HIGH-SPEED FERRIES

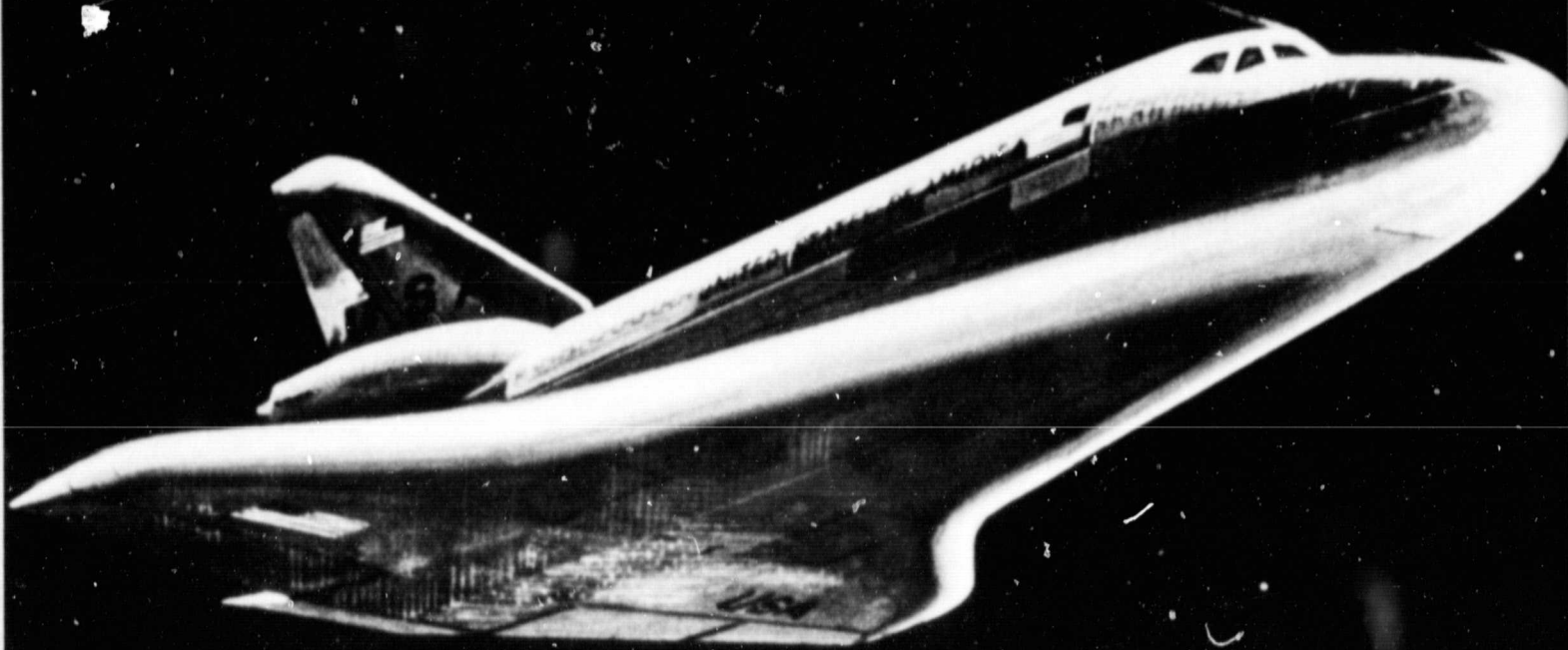
The lightweight, high-speed ferries on San Francisco Bay often encounter docking difficulties due to 20-25 knot southerly winds and strong ebb tide currents. As a ferry slows for a docking approach, rolling wave motions can uncover the vessel's jacuzzi pump inlet located well outboard on the bottom of the hull. Pumps then lose suction, and the ferry's gas turbines cease operating. Control of the vessel is lost, and the boat is likely to veer away from the dock.

The SRI Team uncovered a NASA patent entitled "Docking Structure for Spacecraft" which contained relevant technology for transfer to a more advanced ferry docking system. The NASA structure, which was used for joining two spacecraft, meets three essential requirements of a water-based docking system: high energy absorption, automatic latch-up and separation, and large

load-carrying ability.

The application of this particular NASA spacecraft docking technology appears to be feasible. Mr. Robert Belew, developer of the docking structure at NASA's Marshall Space Flight Center, and Mr. Rex McCardell of the Golden Gate Bridge, Highway, and Transportation District have reviewed its practical advantages for ferry docking in San Francisco. Attention is now being given to cost considerations.

In the meantime, NASA engineers have made many additional suggestions for improving terrestrial docking systems. These suggestions have gone directly to the Golden Gate Superintending Marine Engineer. The application of one of these technologies, or a combination of them, may be considered if costs for the spacecraft docking system prove to be too high.



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Shuttle

FIRE RESISTANT MATERIAL

To increase passenger safety in case of fire in a rapid transit car, especially in the confines of a tunnel, the fire resistance of materials need improvement. Improved materials are constantly being sought for seat cushions, seat covers, thermal and acoustic insulation, wall and ceiling panels, floor covering and carpeting, and wire insulation. This problem has remained an important one in the transit industry for years and is especially critical to the San Francisco Bay Area Rapid Transit District (BART) because of a major fire. On January 17, 1979 during the evening rush hours, a BART rapid transit train caught fire and burned in the transbay tube between San Francisco and Oakland. The fire resulted in the death of one fireman, injuries to 46 firemen and passengers, five destroyed BART cars, and damage in the transbay tube. The fire had a big impact on the Bay Area and was front page news for weeks.

NASA's fire resistant materials research stems from the Apollo spacecraft fire in 1967. Under the FIREMEN (Fire Resistant Materials Engineering) program, NASA is emphasizing the exploration of advanced materials and materials systems concepts, many of which challenge state-of-the-art capabilities in compounding, processing, and manufacturing.

The majority of the materials development work of FIREMEN has been conducted at the John-

son Space Center (JSC). Recognizing that the FIREMEN materials would be easily transferrable to the transit industry when they are ready for use, the SRI Team has been following the FIREMEN program during the past few years.

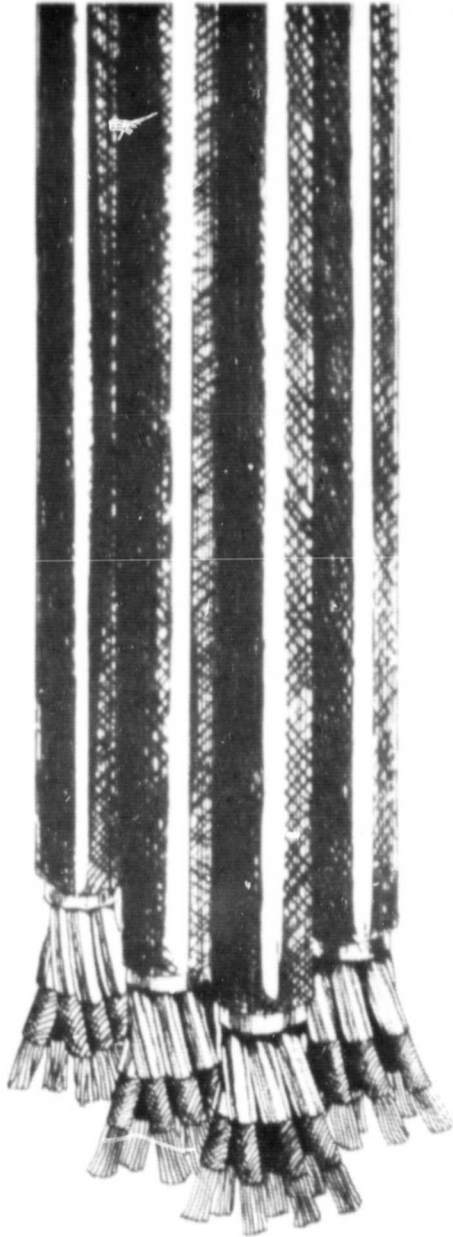
A new fire resistant polyimide foam, developed by Solar Turbines International under contract to JSC, was recognized as a candidate for technology transfer to the transit industry, with BART having the most immediate need. Consequently, the SRI Team arranged for two BART engineers and a California Public Utilities Commission engineer to witness a full scale test of seat cushions made of the polyimide at JSC in June 1979.

Impressed with the JSC test results, BART tested samples of the polyimide themselves. Based on their tests, the BART engineers were ready to recommend that the polyimide be used to replace the polyurethane seat cushions in the BART cars in early 1980. However, Solar Turbines International will not have large production quantities available for sale until late 1980. BART did, however, purchase some of the rigid polyimide foam for use as the core of the BART car end doors.

Since this polyimide, called Solimide, is inexpensive compared to other fire resistant foams and can be made in resilient and rigid form, it could be used to increase the fire safety of rapid transit seat cushions as well as wall, floor, and ceiling panels.



SMOKELESS WIRE INSULATION



The hazard of fire has long been a concern to the transportation industry. Fire is particularly critical in confined areas such as subway tunnels and compartments on ships. Recent studies have shown that incapacitation or death is more probable from smoke than from fire. In the crowded, confined environment of a rapid transit vehicle, a subway, or a ship compartment, it is essential that smoke emission from all sources be minimized. The hazard of smoke inhalation is compounded by the hazard of dense smoke obscuring egress paths as well as hampering fire fighters.

Large amounts of insulated wire and cable are situated in subway tunnels, on rapid transit cars for power, signals, and communications. Because of several subway fires in the early 1970s during which burning wire and cable insulation propagated the fires and created much smoke, the rapid transit industry placed high priority on a search for an affordable smokeless wire and cable insulation material.

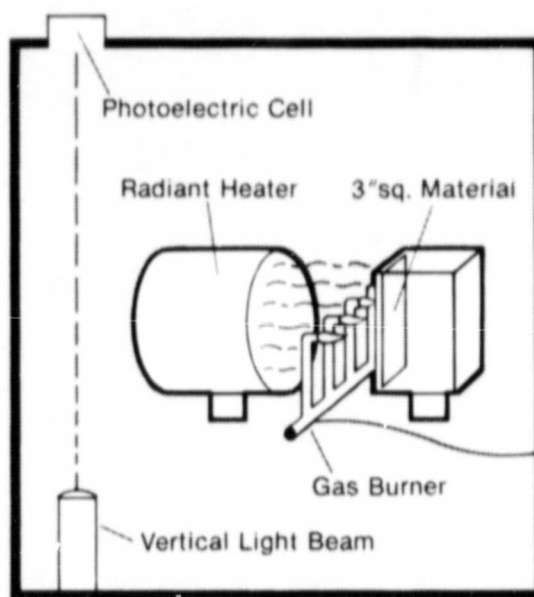
As a result of the SRI Team's dissemination of a problem statement in April 1974, JPL suggested that multimodal or bimodal distribution could be used to load a binder with inorganic fillers, thereby reducing the portion of the material (i.e., the binder) that will burn and smoke extensively.

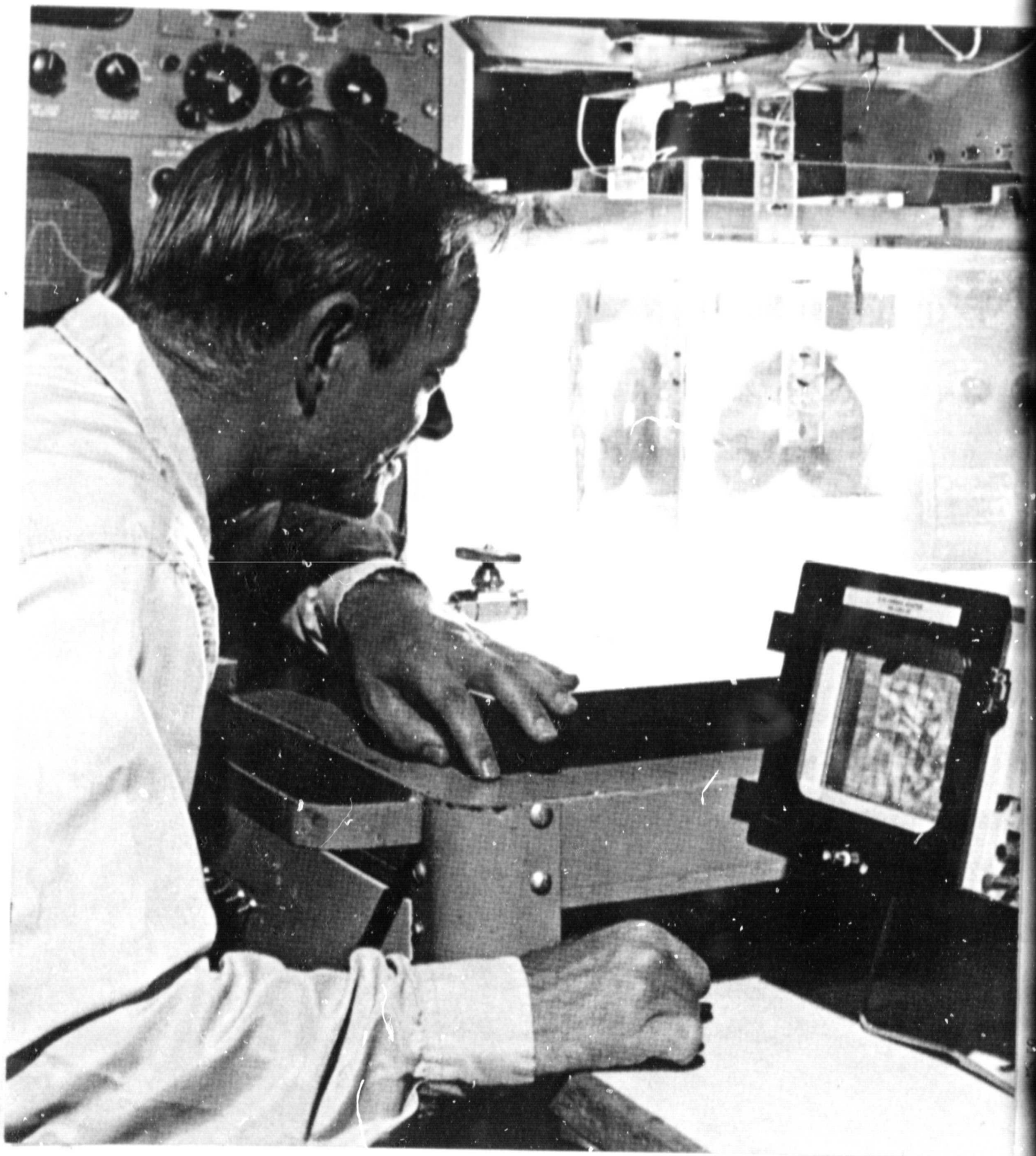
Bimodal distribution technology has been successfully used by NASA to fill solid rocket propellant binders with up to 86% by weight of oxidizer. To understand the bimodal packing theory, one might visualize a dense packing of spheres all of the same diameter. Then between these spheres, a packing of other spheres of a diameter that just fit into the voids between the first set of spheres. The extension of this bimodal distribution would be a multimodal distribution.

JPL began an applications engineering project in 1975. JPL has now found that 67% by weight total filler (i.e., 62% $\text{Mg}(\text{OH})_2$ and 5% additives) with EPDM rubber is the optimal formulation to minimize smoke and flammability and provide mechanical strength. This research was completed by the end of FY 1978.

The SRI Team has arranged for the commercialization of this technology. An interested manufacturer, Boston Insulated Wire and Cable Company, has obtained sufficient information on the $\text{Mg}(\text{OH})_2$ /EPDM material and on multimodal distribution technology to allow the company to determine the technical feasibility of applying the technology for commercialization.

The company has recently reported that the bimodal distribution technology has been successfully adapted and applied to improve some of their commercially available products. A significant improvement in the physical properties of the company's low-smoke and flame-retardant wire insulation, used in the rapid transit industry, has resulted. This product is expected to be commercially available to rapid transit properties in 1980.





General & Ongoing Research

AN IMPROVED TRUCK MUFFLER DESIGN

In the Noise Control Act of 1972, Congress established a national policy to promote a noise free environment for all Americans. Since that time, the EPA has determined that medium- and heavy-trucks are the major contributing noise source on our local, state, and national highways. In an attempt to eliminate this source of noise pollution, the EPA established Federal Regulation Part 205. This standard, which appears in *The Federal Register* (Vol. 41, No. 72, Title 40), specifies maximum allowable A-weighted sound pressure levels, measured at a distance of 50 feet from the longitudinal center line path of a vehicle traveling at 35 mph.

The standard and effective dates are:

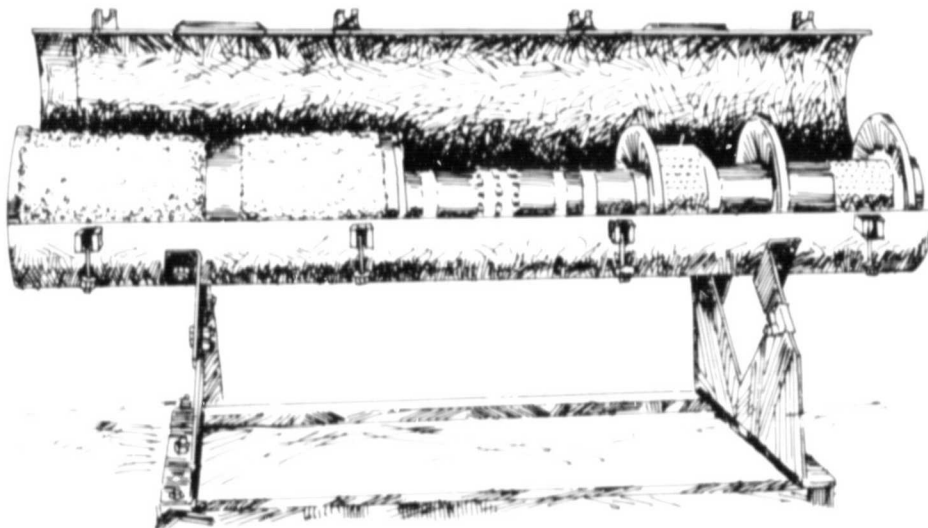
Maximum Sound Level (dBA)	Effective Date
83	January 1, 1978
80	January 1, 1982
(reserved)*	June 1, 1985

One way to meet the new regulations is to improve the exhaust mufflers of medium- and heavy-duty trucks. A new truck noise suppression

device should be more efficient than the present ones, more compact, and have a price similar to that of mufflers now on the market.

Having recognized noise suppression as a significant national problem, the SRI Team had previously identified the noise suppressor described in NASA Tech Brief 74-10261. This noise suppressor, developed at LRC, consists of multiple bands of acoustically absorbent liners on the inside wall of a duct that forms an acoustic trap that uses the reflective elements on the ends to direct sound into the sound-dissipating element in the center. It is capable of doubling the noise attenuation of a conventional muffler at peak noise level. The patented noise suppressor was designed for use in turbofan aircraft engine inlet and exhaust ducts.

Manufacturing interest was developed through contact with the Donaldson Company, a heavy-duty truck muffler manufacturer. After review and discussion with Dr. William Zorumski, the NASA innovator, the Donaldson Company has decided that it would like to develop and evaluate a truck muffler using the LRC segmented liner technology. As a result of a visit to Donaldson's corporate office



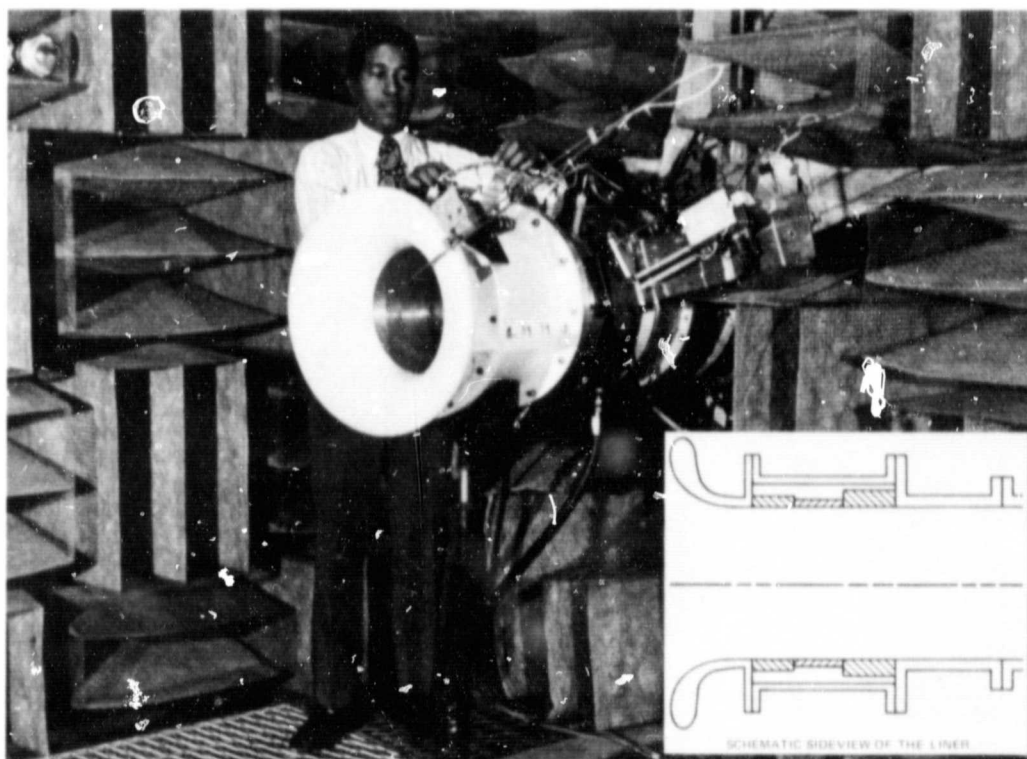
and R&D center in Minneapolis, Minnesota, the SRI Team concluded that the Donaldson Company has the capability and desire to develop, test, manufacture, and market a segmented liner truck muffler based on the NASA technology.

In August 1977, Donaldson Company began the evaluation project of the segmented liner for use as a heavy-duty truck exhaust muffler. A one-day meeting was held at LRC to begin the transfer of LRC segmented liner technology for truck muffler development. The theory behind the LRC noise suppressor design was discussed, as well as the associated LRC computer program to suggest design specifications for use in building an experimental segmented liner truck muffler. Since August

1977, excellent communications have been established between Donaldson and LRC. The SRI Team now serves mainly as an observer to ensure a smooth transfer and proper recognition for the NASA technology.

The Donaldson Company plans to develop an over-highway truck muffler and/or a gas turbine muffler. To have a truck muffler that meets the 1982 EPA standard, a workable design should be delivered from R&D to product engineering in 1980.

*This standard is expected to be in the 76- to 77-dBA range.



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CORROSION PROTECTION FOR MODERN VESSELS

The U.S. National Electrical Code requires that docked vessels be properly grounded whenever commercial electrical power is used on board. In California, an unexpected side effect of grounding the Golden Gate Bridge 'Highway and Transportation District' aluminum-hulled ferries has been a significant increase in corrosion below the waterline. Although devices to stop this type of corrosion are commercially available, none has been approved by the U.S. Coast Guard. The District turned to NASA for a solution.

In response to a request by the SRI Team to investigate the problem, Mr. Ernest Iufer of NASA's Ames Research Center made an in-depth tour of the ferry facilities. He concluded that if the materials used in the dockside ground rods were to be changed from iron and copper to a material that closely matches the electrolytic-solution potential of the ferries, then the galvanic current in the ground system would be reduced to negligible values. This in turn would solve the electrolytic

corrosion problem.

Grounding systems using nonferrous alloys are not in common use but are permitted by the National Electrical Code. It was suggested that aluminum alloy AAA-5086 be considered for the dockside ground rods. This alloy contains 4.9% magnesium and 0.5% manganese and is well suited for marine use. A properly designed rod of this material will outlast iron in a marine environment. Approved connectors for attaching the copper ground lead to aluminum are commercially available.

The Golden Gate Bridge, Highway, and Transportation District was pleased with the prompt and cost-effective solution provided by NASA, particularly since it had exhausted normal industrial sources of information before contacting the SRI Team. In 1979, the NASA-designed nonferrous grounding system was installed at all three berths of the Larkspur Ferry Terminal.



AERODYNAMIC DRAG REDUCTION

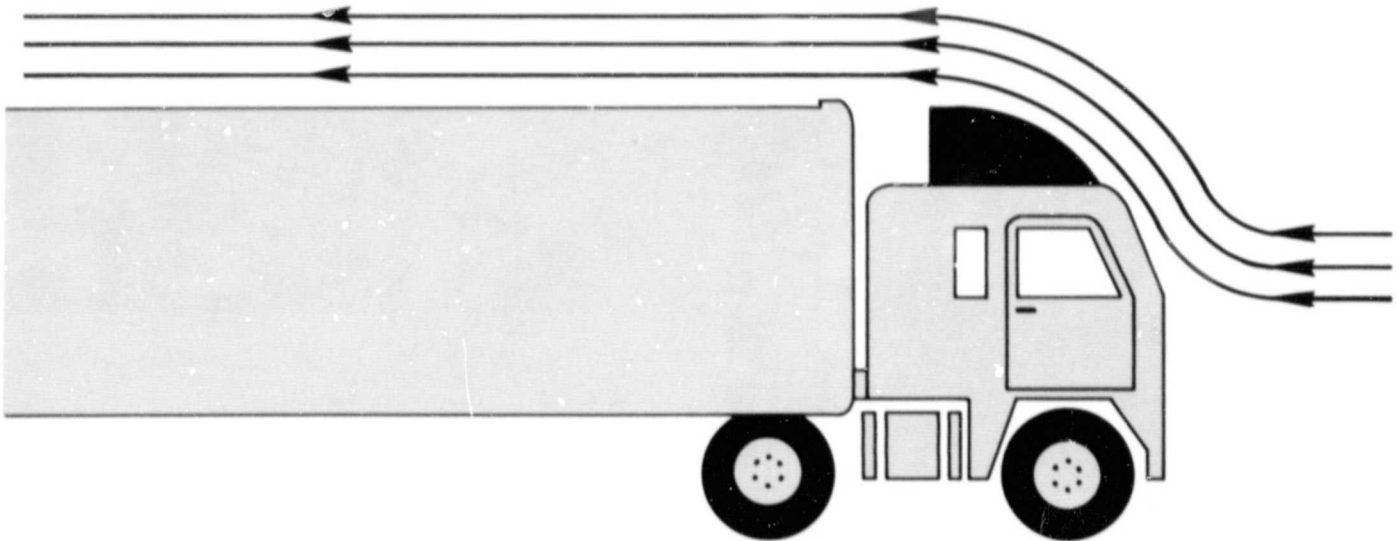
Present-day truck shapes are designed with consideration of air drag factors; however, these factors are balanced with the concept of "cube." The term "cube" relates to the packing factor on a truck, and simply stated, implies that square boxes do not fit rounded corners.

In the light of current energy considerations, the cube concept is less valid than in previous years. Truck manufacturers are interested in new, streamlined design concepts to minimize air drag and increase energy efficiency.

The SRI Team learned that engineers at Dryden Flight Research Center (DFRC) have been working, under U.S. DOT funding, on improved aerodynamic shapes for semitrailer trucks. Results to date have shown that with only minimal modification

of existing truck design, frictional drag can be reduced more than 50%, thereby cutting fuel costs by 30% at normal operating speeds.

A visit to DFRC enabled the Team to gather more information and to witness actual air drag tests. From these tests, it was evident that as fuel conservation becomes a major issue, the trucks in the 1980s must have a more streamlined configuration. To achieve this goal, the Team suggested to the trucking industry that aerodynamics modeling as well as a complete truck dynamics model would aid in reaching this objective in the shortest possible time. The Team presented the DFRC test results and the engineering design innovations developed at DFRC to leaders of the trucking industry. Many of today's aerodynamic designs may be traced to this Team effort.



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GLOSSARY

NASA Centers

NASA HQ	NASA Headquarters
NASA HQ TU	NASA Headquarters Technology Utilization
ARC	Ames Research Center
DFRC	Dryden Flight Research Center
GSFC	Goddard Space Flight Center
JSC	Johnson Space Center
KSC	Kennedy Space Center
LRC	Langley Research Center
LeRC	Lewis Research Center
MSFC	Marshall Space Flight Center
NSTL	National Space Technology Laboratories
JPL	Jet Propulsion Laboratory

Department of Transportation (DOT) Codes

FRA	Federal Railroad Administration
FHWA	Federal Highway Administration
UMTA	Urban Mass Transportation Administration

Miscellaneous Abbreviations

AP	Applications Project
BART	Bay Area Rapid Transit District (Oakland, California)
EPA	Environmental Protection Agency
GC	Gas Chromatograph
MARTA	Metropolitan Atlanta Rapid Transit Authority
NDE	Nondestructive Evaluation
RTOP	Research and Technology Objectives and Plans
TAT	Technology Applications Team
TU	Technology Utilization
TUO	Technology Utilization Officer

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